

some significant changes take place. Although engineering has provided the technology for preventing most fatalities due to tractor rollovers, it appears that voluntary implementation is very slow.

In Sweden a very significant reduction in tractor rollover fatalities has been brought about by requiring rollover protection on farm tractors.<sup>11</sup> Between 1961 and 1983, Sweden was able to drop its annual fatality rate for tractor overturning from 12 per 100,000 farmers to 1 per 100,000 farmers. This was accomplished through regulations introduced periodically between 1959 and 1981.

It will take cooperative action, including input from farmers, to develop creative prevention programs to solve this difficult problem. Education, enforcement, and engineering will work if they are supported by the common interest of a united agricultural

public health community. Achieving this unity is a crucial goal for the 1990s. □

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## ABSTRACT

This study evaluated pulmonary function in workers from 39 autobody repair shops. Based on 152 White male workers with known smoking status, the mean percent predicted FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC were 93.6, 96.8, and 96.6, respectively. Twenty-three percent of workers had a FEV<sub>1</sub>/FVC ratio less than the fifth percentile. Isocyanate levels ranged from nondetectable to 0.06 parts per million (STEL = 0.02 ppm). No shop had an adequate respiratory protection program. We concluded that there was an increase in abnormal pulmonary function in autobody workers. Three recommendations were made to shop owners: functional paint booths should be maintained, respiratory protection programs should be developed, and isocyanate-free paints should be used. (*Am J Public Health*. 1991; 81:768-771)

# A Cross-sectional Study of Pulmonary Function in Autobody Repair Workers

David L. Parker, MD, MPH, Kirsten Waller, MD, MPH, Brenda Himrich, MS, Anita Martinez, MS, and Frank Martin, PhD

## Introduction

Approximately 700 autobody repair shops employ an estimated 3,500 individuals in Minnesota (Minnesota Department of Labor Relations, Personal Communication). Autobody repair involves hammering dents, removing damaged parts, welding, grinding, abrasive blasting, filling with styrene putty, sanding, and spray painting.<sup>1,2</sup> Workers may be exposed to hazards including isocyanates, metals in paint, solvents, dusts, and noise.<sup>2,3</sup> Despite possible adverse health effects,<sup>4-7</sup> there has been little epidemiologic investigation of the autobody repair industry.<sup>1,8-10</sup> This study examines pulmonary function in autobody repair workers.

## Methods

### Sampling Protocol

Autobody repair shops listed in the Twin Cities Yellow Pages were randomly selected for study. Shops were included in the study if: 1) they had 20 or fewer employees; 2) at least half of establishment

income was from autobody repair; and 3) they were located within the Twin Cities metropolitan area. Shop owners were asked questions regarding the inclusion criteria. The owners of eligible shops were asked to participate.

A questionnaire was given to each shop manager regarding shop age, size, number of cars repaired, ventilation, and repair materials. Sampling for toluene diisocyanate (TDI), total particulates, and solvents (acetone, benzene, methyl ethyl ketone, toluene, xylene, trichloroethylene, and mineral spirits) was done in all

Address reprint requests to David L. Parker, MD, MPH, Chronic Disease and Environmental Epidemiology, Minnesota Department of Health, 717 Delaware Street SE, Minneapolis, MN 55440. Ms. Martinez is also with the state health department. At the time of the study, Dr. Waller (now with CDC/EIS) and Ms. Himrich (now with the Department of Risk Management, Hennepin County) were students at the School of Public Health, University of Minnesota. Dr. Martin is Associate Professor in Applied Statistics, U-MN. This paper, submitted to the *Journal* July 17, 1990, was revised and accepted for publication January 23, 1991.

TABLE 1—Characteristics of 39 Autobody Repair Shops

	Mean	Standard Deviation	Range
Number of Workers	3.9	2.6	1–12
Years in Business	18.8	16.0	<1–70
Age of Building	26.4	21.9	<1–90
Repaired each Month	55.4	45.2	9–200

shops. Total isocyanates [TDI and methylene isocyanate (MDI)] were evaluated in 16 shops, lead levels in nine shops, and silica levels in seven shops. Sampling was done in a central work area for three to six hours. Pumps were calibrated before and after each sampling period. Analyses were done according to the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytic Methods.<sup>11</sup>

A self-administered respiratory and work history questionnaire was given to each worker and reviewed with them for completeness. Using American Thoracic Society<sup>14</sup> criteria, pulmonary function was evaluated at the start and end of the work day with a Collins water-sealed spirometer. Measurements consisted of the forced expiratory volume at one second (FEV<sub>1</sub>), forced vital capacity (FVC), and the FEV<sub>1</sub>/FVC ratio. Spirometric values were adjusted for ambient temperature, barometric pressure, age, sex, and height.

### Data Analysis

The shops and workers were characterized using descriptive statistics. Mantel-Haenszel odds ratios, stratified by smoking status (current, past, never) were computed for categorical variables and combined into a single summary odds ratio. Bartholomew's test for trend was used to evaluate the effect of work practices on the proportion of workers with cough or wheeze. Each of the independent variables (e.g. respirator use while sanding) was ordered as: never, sometimes, always.<sup>15</sup>

Percent of predicted FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC were calculated for White males using the equations of Crapo, *et al.*<sup>16</sup> An "abnormal" pulmonary function test was one below the fifth percentile for age, height, and sex. The fifth percentile is a value that is approximately 80 percent of predicted for the FEV<sub>1</sub> and FVC, and approximately 90 percent of predicted for the FEV<sub>1</sub>/FVC.<sup>17</sup> A one sample binomial test was used to evaluate the prevalence of abnormal pulmonary function tests. Morning and afternoon pulmonary function were compared using paired t-tests.

Predictors of pulmonary function were evaluated using stepwise linear regression.<sup>18</sup>

## Results

### Shop Characteristics

Of the 128 shops contacted, seven (5 percent) were out of business, and 52 (41 percent) were not eligible. Of the 69 remaining shops, 59 were asked to participate of which 39 (66 percent) agreed. Ten shops were not asked to participate because *a priori* study enrollment goals had been met.

Table 1 shows the characteristics of the 39 shops studied. Two shops were one-person operations, and all but one were independently owned and operated. Even though most shops (72 percent) did sandblasting, this was rarely done for more than one hour per week. Ten shops had paint booths in a poor or nonworking condition.

Ambient levels for silica were below the detection limit for the seven shops tested. All solvent levels were below the current American Conference of Governmental Industrial Hygienists (ACGIH) guidelines. Total particulates ranged from 0.4 mg/m<sup>3</sup> to 14 mg/m<sup>3</sup>. Particulate levels exceeded 5 mg/m<sup>3</sup> in four shops, and 10 mg/m<sup>3</sup> in one; the current ACGIH guideline for nuisance dusts.<sup>19</sup> Proton-induced x-ray analysis of ambient dusts revealed the presence of small quantities of 20 metals. No ambient lead was detected in the nine shops that were evaluated.

Isocyanate samples were collected from 32 shops. Two samples were lost due to laboratory error. Eight-hour, time-weighted average total isocyanate levels ranged from not detected to 0.06 ppm (mean = 0.005 ± 0.008). The current ACGIH recommended level for TDI and MDI is 0.005 ppm.<sup>20</sup> The highest and lowest isocyanate levels were from the same shop on different days. In three shops, total isocyanate levels were slightly above current ACGIH guidelines. Two to twelve

times the current guideline was exceeded in another four shops.

Of 164 workers, 162 (99 percent) completed questionnaires and 159 (97 percent) performed acceptable morning and 149 (91 percent) acceptable afternoon pulmonary function tests. The mean age was 31.6 years (±11.3), 157 (97 percent) were White and 160 (99 percent) males. The mean years worked in the autobody industry was 11.4 (±9.7). Cigarette smoking was common: 67 (41 percent) current, 30 (18 percent) former, 63 (39 percent) never smokers, and two (1 percent) unknown.

Of the 122 workers who spray painted at least one hour per week, 4 percent never used a respirator while painting, 33 percent sometimes did, and 63 percent always used one. For the 96 workers who did sandblasting these percentages of respirator use were 25 percent, 33 percent, and 42 percent, respectively.

Table 2 shows the number of individuals whose pulmonary function was below the fifth percentile and the mean values of the pre-work percent predicted FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC stratified by smoking status. Among 60 workers who had never smoked, five (8 percent) had baseline FEV<sub>1</sub> or FVC measurements below the fifth percentile. Fourteen (23 percent) had an FEV<sub>1</sub>/FVC below the fifth percentile ( $p < 0.001$ ). No significant change in pulmonary function was seen between the morning and afternoon shifts. In addition, no relationship was seen between shop isocyanate levels and pulmonary function.

By regression analysis, a nonfunctioning paint booth ( $\hat{B} = -8.35$ ), smoking ( $\hat{B} = -3.84$ ), years worked in the autobody industry ( $\hat{B} = -0.20$ ), hours per week sanding ( $\hat{B} = 0.21$ ), doing paperwork ( $\hat{B} = 0.20$ ), and assembly ( $\hat{B} = 0.18$ ) significantly predicted the percent predicted FEV<sub>1</sub>/FVC ( $R^2 = 0.19$ ). Decrements in both the percent predicted FEV<sub>1</sub> ( $R^2 = 0.20$ ) and FVC ( $R^2 = 0.11$ ) were significantly associated with years worked in the autobody industry and a nonfunctioning paint booth.

Summary odds ratios showed a positive, non-significant association between the presence of cough and wheezing\* and 1) failure to have a functioning paint booth, 2) failure to use a respirator, and 3) spray painting and/or sandblasting. Using

\*Cough was defined as coughing four to six times per day at least four days per week. Wheezing was defined as wheezing on most days or nights.

**TABLE 2—Percent Predicted Morning Pulmonary Function and Number of Workers Whose Pulmonary Function Was Less Than the Fifth Percentile by Smoking Status\***

Smoking Category (N)	Mean	Standard Deviation	Number with Abnormal Pulmonary Function (%)**
Never Smoker (N = 60)			
FEV <sub>1</sub>	93.6	11.4	5 (8)
FVC	96.8	11.4	5 (8)
FEV <sub>1</sub> /FVC	96.6	7.0	14 (23)
Former Smoker (N = 30)			
FEV <sub>1</sub>	91.6	13.8	6 (20)
FVC	95.6	13.1	3 (10)
FEV <sub>1</sub> /FVC	95.8	7.4	8 (27)
Current Smoker (N = 62)			
FEV <sub>1</sub>	90.0	15.3	11 (18)
FVC	96.3	13.6	4 (6)
FEV <sub>1</sub> /FVC	93.1	10.0	18 (29)

\*A total of 159 workers completed at least one acceptable spirometric examination. Of these, five non-White workers and two workers whose smoking status was unknown were excluded from the analysis.

\*\*Abnormal is defined as corresponding to less than the fifth percentile. For the FEV<sub>1</sub> and FVC this is approximately 80 percent of predicted and for the FEV<sub>1</sub>/FVC ratio, approximately 90 percent of predicted.

a chi square test for trend, for nonsmokers, the presence of wheezing significantly ( $p < 0.05$ ) increased across the categories of respirator use (always, sometimes, never) while spray painting and for coughing and wheezing while sandblasting. No significant trends were seen for respiratory symptoms and respirator use while sanding.

## Discussion

Two-thirds of all shops contacted agreed to participate. Although no information was available on shops that refused to participate, it is unlikely that they were cleaner than the ones tested. Shops were generally dusty and strong solvent odors were common. Improper respiratory protection was often used, when used at all. These findings are similar to those of Tuskes and Key<sup>1</sup> and Rose, *et al.*<sup>8</sup>

Isocyanate levels were consistent with the mild, but significant, decline in pulmonary function and the presence of respiratory symptoms seen.<sup>20,28</sup> Years working in the autobody industry, and working in a shop with a nonfunctioning paint booth, along with smoking, were associated with a decrement in the FEV<sub>1</sub>/FVC indicative of obstructive disease.<sup>30,31</sup> Time spent doing tasks not involving painting or priming (i.e. sanding, doing paperwork, and assembly) were positively associated with the FEV<sub>1</sub>/FVC. No relationship was found between pulmonary function and ambient isocyanate levels. This was not surprising given the day-to-

day variability in the type and quantity of work done in each shop. The failure to find acute pulmonary changes may be due to the migration of sensitized workers who may have had to find other employment or the fact that it was unusual to visit a shop on a Monday. We did not monitor over the course of the week for delayed asthmatic reactions.<sup>26</sup>

The environment in autobody repair shops may be improved in several ways. Shops should maintain functional paint booths for spray painting, and the spray painting of vehicles in open shop areas should be avoided. Shops should have complete respiratory protection programs and use less hazardous, isocyanate-free paints. □

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## ABSTRACT

Using 1,004 subjects enrolled in a worksite health promotion program, this report evaluated the validity of a single question about participation in regular exercise. Measured at baseline, this one question had a significant age-adjusted association with body mass index ( $p < 0.0001$  in women and  $p = 0.001$  in men), HDL cholesterol ( $p < 0.0001$  in women), and oxygen capacity ( $p = 0.0007$  in women and  $p = 0.002$  in men). Thus, one self-reported question can provide useful information about who is and who is not participating in regular exercise. The potential validity of a single exercise question is particularly relevant in complex epidemiologic studies where lengthy questionnaires highlight the importance of brief instruments. (*Am J Public Health*. 1991;81:771-773)

# Measuring Physical Activity With a Single Question

Kenneth B. Schechtman, PhD, Benico Barzilai, MD, Kathryn Rost, PhD, and Edwin B. Fisher, Jr, PhD

## Introduction

Through its association with low levels of HDL (high-density lipoprotein) cholesterol, obesity, and other physiologic parameters, physical inactivity has been linked to increased morbidity and mortality from a variety of diseases. These include cardiovascular diseases,<sup>1</sup> diabetes mellitus,<sup>2</sup> osteoporosis,<sup>3</sup> and even breast cancer<sup>4</sup> and colon cancer.<sup>5</sup> In light of these etiologic associations, the measurement of physical activity has become a standard component of epidemiologic research, with at least 30 different measurement techniques having been described.<sup>6</sup> Unfortunately, many of these are complex instruments that are associated with excessive costs and time commitments that make them impractical in large-scale epidemiologic studies.<sup>6,7</sup> Thus, there is great value in establishing the validity of brief, easily obtained measures of physical activity.

It is the purpose of the present report to discuss the utility of a single exercise question that was generated by the St. Louis Working Hearts Program. That question was "Do you currently participate in any regular activity or program (either on your own or in a formal class) designed to improve or maintain your physical fitness?" We will investigate the validity of this question by evaluating its association with three parameters that are known to be associated with physical activity: body mass index (BMI), HDL cholesterol, and oxygen capacity.

## Methods

The data discussed herein were generated by Working Hearts, a four-year collaboration between Washington University in St. Louis and a large midwestern communications corporation. All employees at 17 divisions of the corporation were eligible to participate in a multifaceted two-year cardiovascular risk reduction intervention. The intervention included individualized counseling, worksite promotional activities, and 25 awareness seminars and workshops that focused on weight loss, cholesterol reduction, hypertension, exercise, stress reduction, diet, and smoking cessation. Of particular relevance is the fact that the exercise component of the intervention included discussions and workshops, but no regular exercise program. Data on three of the four variables pertinent to this report—exercise behavior, BMI, and HDL cholesterol levels—were sought from all study participants. BMI was de-

Address reprint requests to Kenneth B. Schechtman, PhD, Division of Biostatistics, Washington University School of Medicine, 660 South Euclid Avenue, Box 8067, St. Louis, MO 63110. Dr. Barzilai is with the Division of Cardiology; Dr. Fisher is with the Center for Health Behavior Research, both at Washington University; Dr. Rost is with the Department of Psychiatry, University of Arkansas for Medical Sciences. This paper, submitted to the *Journal* August 2, 1990, was revised and accepted for publication January 23, 1991.